1 Objectives

Your goal for this lecture is to learn how to do the following things:

- Identify and explain the parts of a grammar.
- Define *terminal*, *nonterminal*, *production*, *sentence*, *parse tree*, *left-recursive*, *ambiguous*.
- Use a grammar to draw the parse tree of a sentence.
- Identify a grammar that is *left-recursive*.
- Know about *ambiguous grammars*:
  - Be able to identify, demonstrate, and eliminate ambiguity.
- Define *First Set* and *Follow Set*.
- Compute the First Set from a grammar.
- Compute the Follow Set from a grammar.

2 Definitions

Epsilon Productions A production of the form "E $\rightarrow \epsilon$",
where ϵ represents the empty string.

Right Linear Grammars where all the productions have the form
"E $\rightarrow$ x F" or "E $\rightarrow$ x".

Left-Recursive a production like "E $\rightarrow$ E + X"

Ambiguous More than one parse tree is possible for a specific sentence.

3 Ambiguity

Two common causes:

Double-Ended Recursion Rules like $E \rightarrow E \ + \ E$.

Dangling Else Rules like $E \rightarrow x \ E \ y \ E \ z \ E$
$E \rightarrow x \ E \ y \ E$

4 Problems

Try the following problems. In a few minutes the instructor will go over the solutions. Feel free to work with the person next to you!

1. Draw two separate parse trees for the sentence `2 + 3 * 5` given the grammar
   E$\rightarrow$ E + E
   E$\rightarrow$ E * E
   E$\rightarrow$ integer

2. Now draw a tree for the same sentence using the grammar
   E→ F + E
   E→ F
   F→ T * E
   F→ T
   T→ (E)
   T→ integer

3. Draw two separate parse trees for the "dangling else" example: `if a then if x then y else z`
   E→ if E then E else E
   E→ if E then E
   E→ var

4. Compute the First and Follow sets for this grammar.

$E \rightarrow T\ E'$
$E' \rightarrow +\ T\ E'$
$E' \rightarrow \epsilon$
$T \rightarrow F\ T'$
$T' \rightarrow *\ F\ T'$
$T' \rightarrow \epsilon$
$F \rightarrow (\ E\ )$
$F \rightarrow$ `id`

Shorthand notation:

$E \rightarrow T\ E'$
$E' \rightarrow +\ T\ E'\ |\epsilon$
$T \rightarrow F\ T'$
$T' \rightarrow *\ F\ T'\ |\ \epsilon$
$F \rightarrow (\ E\ )\ |$ `id`